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ABSTRACT

The purpose of the present study was to assess the overall effectiveness of a program of selected mathematical experiences for kindergarten children implemented through an inservice teacher education program. A total of 284 children from 10 public schools participated in the study. A booklet containing suggested teaching methods, special instructional materials, alternative methods for teaching mathematical concepts, and useful references was developed for the teachers. It included a variety of mathematical activities in the areas of set theory, numeration, geometry, and measurement. Supplementary materials, such as weekly and daily plans and a materials checklist, were also included. Activities were related to the child's real-life experiences, level of competence, and interests; and were intended to be interesting, to encourage creativity, and to be easily incorporated into typical kindergarten activities. Three inservice meetings for participating teachers were held following the pretesting of the children. The Comprehensive Mathematics Inventory was used in the study. Despite the lack of control group comparison measures, results indicated that the curriculum design was effective. (Author/ED)

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THE EFFECTS OF A KINDERGARTEN MATHEMATICS PROGRAM IMPLEMENTED THROUGH IN-SERVICE TEACHER EDUCATION

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A number of recent studies have focused attention on the mathematical knowledge of young children (e.g., Rey and Reys, 1970; Dutton, 1963; Heard, 1970; Bjonerud, 1967). Although such studies vary considerably in their methodologies, investigators are consistent in finding that many kindergarten children possess a considerable amount of mathematical awareness, and the mathematical knowledge possessed by these children often can be used in relevant, life-like situations.

Despite the encouraging findings about the mathematical understandings of many young kindergarteners, there appear to be few investigations of curricula that foster such competencies. Generally speaking, mathematically oriented curricula are based on two interrelated themes: First, there are cognitively based models in which the developing competencies of the child are incorporated. Second, there are models that emphasize developing mathematical competencies through varied teaching methods and materials. A third approach, one based on in-service teacher education (Norris, 1969; Dutton and Hammond, 1966; McHugh, 1959) emphasizes use of the mathematical knowledge of teachers. Exploration of teaching methods and materials and increasing the teachers' mathematical knowledge are a part of these studies. Few studies are available which assess the mathematical knowledge of the kindergarten child and which encourage imaginative exploration of teaching materials and methods to facilitate and extend this knowledge. The purpose of the present study was to assess the overall effectiveness of a program of selected mathematical experiences for kindergarten children through in-service teacher education.

This research is based on a portion of that reported in the author's Ph.D. dissertation conducted under the direction of Dr. Charlotte W. Junge,

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Method

Sample

The selected sample consisted of 617 white, predominantly middle class kindergarten children attending 10 public schools in Van Dyke, Michigan. However, due primarily to a chicken pox epidemic, complete data were available for only 284 of these children (143 boys and 141 girls).

Curriculum

Prior to initiation of their study, a Kindergarten Mathematics checklist consisting of categories including mathematical concepts related to set theory, numeration, geometry, and measurement was sent to 20 experts in mathematics education and early childhood education with an accompanying letter requesting their opinions regarding the teaching of these concepts in kindergarten mathematics. Their answers provided the base for curriculum content selection. The resulting instructional booklet titled "One and One More" was designed to include a variety of mathematical activities in the areas of set theory, numeration, geometry, and measurement. This booklet contained suggested teaching methods, special instructional materials, alternative methods for teaching mathematical concepts, and references for teachers' use. Additional procedures, forms, and materials were developed to provide organizational continuity and to facilitate efficient implementation of the evaluation of the program's effectiveness. These supplementary materials included weekly plan logs, daily enrichment plans, a kindergarten materials checklist, and a teacher personal data checklist.

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All these materials were prepared for teachers in accordance with the rationale that they be related to the child's real-life experiences, his level of competence, and his interests. Furthermore, they were intended to be interesting, to encourage creativity, and to be easily incorporated into the everyday ongoing activities of the kindergarten. The prescribed individual activities, group sessions, art, music, literature, and games were intended to encourage creative and manipulative mathematical activities. A daily period of 20-30 minutes was set aside for these activities and teachers evaluated each activity by entering notations in a weekly log. In order to implement the experimental curriculum effectively, three in-service meetings were held with the 11 teacher volunteers following the pretesting of the children. One additional meeting was held after the posttest as means of reporting the results of the study to participating teachers. Details of the program itself, as well as its development, can be obtained from Lazarus (1972).

Instrumentation

The Comprehensive Mathematics Inventory (Reys and Rey, 1968) was administered for the study. All children were tested individually according to standard instructions. The thirteen scales included in the Comprehensive Mathematics Inventory, and the abilities measured by the scales, follow:

Money Identification. Ability to recognize coins.

Making Change. Ability to recognize value of coins, ability to solve

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simple word problems.

Vocabulary. Ability to follow one step directions, involving use of specific words, directional words, numerals, rote and rational counting through 20, knowledge of before and after number concepts. Ability to follow directions with vocabulary such as "pair", "few", "many". Size ordination, recognition, recognition of numerals, ability to follow one-step direction by naming objects, counting objects, pointing to correct numerals, one-to-one correspondence, conservation, directionality, were included.

Depth Perception. Ability to distinguish near from far.

Fractions. Ability to recognize ½ and ¼ pie.

Weight. Ability to distinguish differences in size and weight of objects.

Geometry. Ability to recognize, match, know properties of geometric shapes, lines.

Time. Ability to tell time on hour, half-hour, minute; ability to recognize and use calendar and to know days of week, months, child's birthday.

Measure. Ability to recognize and to use yardstick, ruler, thermometer, scale.

Memory. Ability to repeat numeral sequence after 5 second interval.

Auditory. Ability to repeat an auditory numeral sequence.

Tap. Ability to repeat tapped numeral sequence.

Tactile. Ability to repeat tactile numeral sequence.

Procedures

Data were gathered by 15 Wayne State University Juniors and Seniors who were trained through a series of seminars, informal meetings, and

Table 1

Rotated Factor Pattern

Variable	Factor				
	I	II	III	IV	h_j^2
Tap	.84				.71
Tactile	.54				.36
Vocabulary		.75			.84
Memory		.47	.35		.48
Geometry		.45			.45
Weight		.39			.15
Time			.71		.55
Measure			.48		.28
Making Change				.63	.45
Money		.52		.46	.52

Note--loadings with absolute values less than .35 are not reported.

Table 2

Means and Standard Deviations of Pretest, Posttest, and Differences For Ten Dependent Variables and Means of Four Factors Broken Down by Sex

Variable		Boys (N = 143)			Girls (N = 141)			Total (N = 284)		
		Pre	Post	Diff.	Pre	Post	Diff.	Pre	Post	Diff.
Factor I (Tactile)		-.08	.15	.23*	.09	.30	.21*	.00	.22	.22*
Tap	M	3.73	4.02	.29	3.93	4.19	.26	3.83	4.11	.28
	SD	1.18	1.12		1.18	1.01		1.18	1.07	
Tactile	M	2.89	3.39	1.50	3.05	3.40	.35	2.96	3.39	.43
	SD	1.40	1.18		1.32	1.25		1.38	1.22	
Factor II (Verbal)		-.02	.30	.32*	.02	.22	.20*	.00	.26	.26*
Vocabulary	M	57.87	64.51	6.63	53.21	63.54	5.33	58.04	64.03	5.99
	SD	13.71	10.45		12.14	10.64		12.95	10.54	
Memory	M	2.47	2.84	.37	2.57	3.26	.69	2.52	3.05	.53
	SD	1.41	1.40		1.48	1.43		1.45	1.43	
Geometry	M	32.66	33.73	1.07	32.84	33.89	1.05	32.75	33.81	1.06
	SD	4.94	4.61		4.75	4.38		4.85	4.49	
Weight	M	4.10	3.85	-.25	3.97	3.78	-.19	4.04	3.81	-.23
	SD	.93	.40		1.16	.55		1.05	.48	
Factor III (Measurement)		.11	.39	.28*	-.11	.37	.48*	.00	.38	.38*
Time	M	5.44	6.36	.92	4.72	6.09	1.37	5.08	6.23	1.15
	SD	2.50	2.60		2.14	2.28		2.42	2.44	
Measure	M	4.40	5.27	.87	4.09	5.10	1.01	4.25	5.18	.93
	SD	2.72	2.63		2.34	2.40	2.54	2.52	2.52	
Factor IV (Money)		.03	.12	.09	-.03	.04	.07	.00	.08	.08
Making Change	M	1.71	1.78	.07	1.60	1.64	.04	1.65	1.71	.06
	SD	1.43	1.71		1.30	1.70		1.37	1.71	
Money	M	10.22	11.20	.98	10.26	11.00	.74	10.24	11.10	.86
	SD	3.30	3.08		2.84	2.92		3.08	3.00	

*p less than .01

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observations of test administration of the Comprehensive Mathematics Inventory. Both pre- and posttests were administered in two parts: First, the money identification, making change, and vocabulary subscales of the Comprehensive Mathematics Inventory were administered; Second, on a separate day, the remaining portions of the inventory were completed. This procedure insured that testing sessions would not be so lengthy as to exceed the limits of a child's attention span. Although quite varied, the typical time per session was approximately 30-to-40 minutes. Each tester recorded individual pupil responses on the Inventory test booklets, and these data were later transferred to individual pupil data sheets. Children were tested prior to the onset of the program (pretest) and following its conclusion eight weeks later (posttest).

Analysis

To test each pre- to posttest change of the 13 criterion scales individually for significance is inappropriate because such a procedure ignores the complex interdependencies among the measures. Therefore, in order to parsimoniously interpret the multivariate data from the various subscales of the Comprehensive Mathematics Inventory, a general factor analysis of pretest scores was conducted:

First, a 13 x 13 correlation matrix was generated and a principle components solution obtained using the Statistical Package for the Social Sciences computer package (see: Nie, Bent, and Hull, 1971).

Second, the 13 eigenvalues of the correlation matrix (Part of the Statistical Package for the Social Sciences output) were plotted graphically

in the serial order of their magnitude. A scree test was conducted to decide on the number of factors to be specified for further analysis (Cattell, 1966). Four factors were indicated by this test.

Third, a principal factor solution was obtained assuming the presence of four common factors. A five-factor solution was also obtained, but the additional factor was found to be specific.

Fourth, the resulting four-factor solution was rotated according to the Varimax criterion to simple structure. An oblique solution was also attempted, but the resulting factors were less satisfactory for interpretation.

Fifth, factor score coefficients were obtained for each of the resulting four common factors (another standard output of the Statistical Package for the Social Sciences program).

Factor scores were obtained for each child in the sample on both the pretest and posttest using the pretest factor score coefficients as weights. In this manner the number of criteria on which changes in performance were registered was reduced from 13 intercorrelated scales to four independent factors. The sample was broken down according to sex, and t-ratios for correlated samples used to test the significance of each pre- to posttest change for males and females on the four factors.[1]

Results

The four factor solution accounted for approximately 58% of the total variance of the measurement battery. Communalities ranged from a low of

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[1]Dr. Herbert C. Richards, University of Virginia, helped with the analysis of these data.

.12 (Fractions) to a high of .84 (Vocabulary), with a median communality of .45. Measures with loadings exceeding an absolute value of .35 are reported in Table 1 together with their communalities (h_j^2). Measures not reported due to insufficient loadings on one or more of the common factors were: Depth Perception, Fractions, and Auditory Discrimination.

Significant ($p<.01$) pre- to posttest changes were found on Factors I, II, and III, but almost no change took place on Factor IV. These results were consistent for both the total sample and for boys and girls viewed separately. Table 2 presents both these findings and descriptive statistics for the individual scales loaded on each factor.

Discussion

As with many other studies of experimental curricula, the present investigation suffers from the lack of a suitable control group. Therefore, it may be argued, that the performance changes reported in Table 2 reflect developmental growth (or possible Hawthorne effect) as much as possibl effects of the experimental program. However, the present author finds it difficult to imagine how any influence other than the experimental curriculum could have effected change specifically on Factors I, II, and III (factors that included variables targeted by the experimental program) leaving Factor IV unaffected. It is at least plausible to believe that changes were due largely to intervention, although undoubtedly other uncontrolled variables exerted some influence.

A second criticism directed toward many studies of intervention effectiveness, that curricula are designed to specifically train children

to do well on the criterion measures (i.e., training in test taking), cannot be applied to the present investigation. Not only were teachers uninformed as to the criteria used (at least until after the data on the children were obtained), but the Comprehensive Mathematics Inventory was selected as a criterion instrument after curricular materials and methods were developed. This procedure insured the conceptual and operational independence of the experimental program from the selected criteria.

The four factors emerging from the pretest data are both statistically and conceptually meaningful, and each will be discussed separately.

Factor I. As can be seen in Table 1 this dimension consists of the Tap and Tactile subscales of the Inventory and has been named the "tactile" dimension. The finding that these scales group together empirically corroborates earlier studies indication that tactile and auditory discrimination are highly related abilities. Measured ability on this dimension changed significantly over rhw eight week period (see Table 2).

Factor II. This category includes the subscales vocabulary, memory, geometry and weight and is entitled "verbal" in Table 1. These dimensions include cognitive, verbal, motor skills which are interrelated. Abilities measured changed significantly (see Table 2).

Factor III. As indicated in Table 1, this dimension consists of Inventory subscales Time and Measure which are concerned with measurement related to time (recognition and functions of clock and calendar) and with various measurement devices and their uses.

Significant changes occured in this area as is shown in Table 2.

Factor IV. This factor includes abilities related to money and making change and did not change significantly over the eight week period (see Table 2). Empirically these dimensions are consistent with other studies.

The results thus indicate strongly that the curriculum design was effective. A fruitful continuation would be the use of this curriculum with an experimental-control research design. Possible alternative approaches include use of a rural population, use of curriculum without in-service training of teacher, and use of curriculum over longer time period.

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